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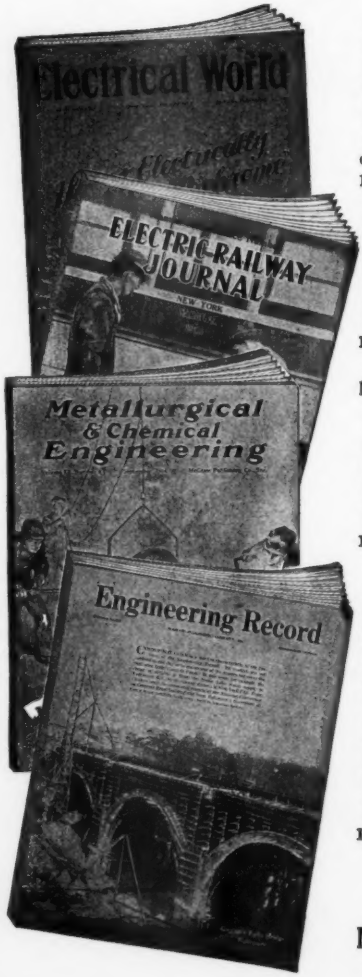

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AN EXPERIMENT IN COÖRDINATION OF MATHEMATICS WITH ENGINEERING SUBJECTS.

BY R. E. ROOT,

Professor of Mechanics and Engineering Mathematics, Post Graduate Department, U. S. Naval Academy.

In a technical sense, an experiment consists in designedly bringing about certain conditions and relations among elements in order that resulting phenomena may be observed, with a purpose to test the truth of certain hypotheses or to furnish a basis for new hypotheses. The undertaking that is the subject of this paper is not an experiment in this technical sense, but rather in the more general sense that many unique and untried features are found in the conditions present, and that careful attention is given to observation of results, both for guidance in future efforts in the same undertaking and for the light that may be shed upon the general problem of which this is a special case. The dominating motive in fixing those conditions that are under control has been a desire for good results, rather than for information concerning methods of obtaining results.

Certain features of the general situation on which this experiment is thought to bear may be stated very briefly. After a rapid development and extension of technical education it was recognized that the students in technical courses were handicapped by lack of mathematical ability, even though they had received liberal instruction in those branches of mathematics they were required to apply.

Proficiency in the mathematics courses as given, and as developed in the "arts" colleges, seemed to have slight rela-

tion to facility in application of mathematical principles and processes in the treatment of technical problems.

Alert teachers of mathematics were quick to see and admit the situation, and to seek remedies. Recent years have brought about radical changes in methods and aims of instruction and in content of courses in mathematics in engineering and pre-engineering curricula. These departures from the traditional courses differ in degree and diverge in character in different institutions. The transition is still in progress, the new features not yet standardized.

Meanwhile teachers of engineering subjects have recognized that the remedy does not lie entirely with the mathematicians. The fact that students from the traditional mathematics courses were qualified for advanced work in pure and applied mathematics given in the departments of mathematics indicated that the fault lay, not in lack of efficiency in mathematical instruction, but in lack of coördination between courses. Toward the solution of the problem of coördination the technical teachers have contributed very largely.

The effort at coördination of which we write concerns the work of the postgraduate department of the Naval Academy. The students are naval officers, graduated from the Naval Academy, and, for the most part, with five or more years experience in the service as commissioned officers. The curriculum is engineering, one year at the Naval Academy in fundamental and general subjects, followed by one or more years of work of more divergent and specialized character, at present in other institutions.

The four years' undergraduate course at the Naval Academy is not primarily an engineering course. In the two years' course in mathematics time is required for review of plane and solid geometry, and emphasis is placed on spherical trigonometry and stereographic projection, on account of their importance in navigation, so that the time available for calculus is inadequate, and the course incomplete. The one semester course in mechanics is divided into three parts,

mechanics, strength of materials, and hydromechanics, the treatment of each being necessarily brief and elementary. Elementary courses in physics and chemistry are given in the second year. Mechanical drawing is covered during the first and part of the second year, and somewhat less than half of the curriculum of the last two years is devoted to subjects in electrical and mechanical engineering. These engineering courses may be characterized briefly as descriptive and empirical, rather than theoretical.

The student officer comes to the postgraduate department with a fund of practical experience, a mature judgment, and a keen appreciation of the need of technical training. As to preparation, his situation is such as to require a review of many of the fundamental mathematical and scientific principles on which engineering theory is based.

The problem of providing adequate mathematical training for these officers is made more acute, here even more than in the average engineering school, by a very crowded curriculum, forcing the work into a minimum of time. Another condition affecting our problem is that the student must start his fundamental courses in electrical and mechanical engineering at the same time that he begins his courses in mathematics and mechanics. A feature favorable to our experiment is that, up to the present time, the number of students has been sufficiently small to permit the professor in charge of each course to come in direct contact with every student in the course. Coördination between courses is facilitated by the fact that daily contact and interchange of ideas among the entire postgraduate faculty is a natural consequence of the small number concerned.

The professor in charge of mathematics has charge also of mechanics. In the general engineering curriculum each of these subjects is allowed two recitations or lectures per week throughout the year. The mathematics course must include a review of the essentials of algebra, trigonometric transformations and equations, analytic geometry, the meaning of and

processes of differentiation and integration. It must include also Taylor's theorem with applications, empirical equations, precision of measurements, approximate integration, complex variable notation and operations, trigonometric series, partial derivatives with applications, and differential equations. The course in mechanics must include the principles of statics, applications to framed structures; distributed forces, simple stress-strain relations, combined stresses, application to beams, shafts, columns, flat plates, thick cylinders, curved members; the principles of dynamics, friction, efficiency of machines, velocity and acceleration diagrams, piston and crank effort curves for reciprocating engines, flywheels, balancing; the gyroscope.

The conditions we have enumerated would seem to render quite obvious the method of attack of our problem. Effort has been made along three principal lines: (1) The material of both courses, but especially of the mathematics course, has been carefully scanned, to eliminate all non-essentials, and the treatment of each topic is as brief as is consistent with clear understanding of the principles and processes. (2) Effort is made to arrange the topics in both courses so that the logical and systematic introduction of each new principle or process precedes its use in any other course. (3) When application is made in one course of material developed in another, conscious effort is made to connect with the former treatment, so that the students' grasp of the material is reinforced rather than shaken.

These three lines of effort are interrelated. The treatment of a topic will depend partly upon its place in the course, and upon the applications to be made of it. All three points, and especially the third, depend in part upon the coöperation of professors in charge of other courses. In the matter of order of topics there is more latitude than might be supposed. For example, it makes little difference whether the idea of derivative is first introduced in mechanics in connection with velocity and acceleration, or in mathematics in the usual man-

ner, provided that in either case it is presented clearly and effectively. Approximate integration may arise first as an abstract proposition concerning areas in mathematics, or as a device for treating a beam with distributed load. Polar moment of inertia may, without disadvantage, be first defined in relation to the resistance to twisting moment in a shaft. On the other hand, the complex quantity in mathematics and harmonic motion in mechanics might almost as well be omitted if their treatment does not precede their use in the theory of electricity. Difficulties of arrangement arise, not in the relations between mathematics and mechanics, but in the relations between these courses and the theory of electricity, thermodynamics, and machine design. The number of technical courses running parallel with our courses in mathematics and mechanics presents problems of arrangement that can hardly be met with entire success. This difficulty, which would scarcely arise under conditions that prevail in most schools, is partially relieved here by the fact that the student retains, from his introduction to these subjects as a midshipman, a partial working knowledge of the elements of the subjects.

Space would not permit a description in detail of our efforts along the three lines indicated. It may be permitted, however, to state what we regard as some of the advantages of the general plan in operation. In the first place it leads to economy in the time of the student. When a course in mathematics precedes all courses in which it is applied a liberal number of problems illustrating each principle must be assigned. Under our plan the problems in mechanics serve to illustrate the mathematical principles involved as well as the principles in mechanics, making it possible to reduce the number of problems assigned in mathematics. Also the work in mechanics is facilitated by the freshness of the mathematics in the mind of the student. The reactions between these courses and the technical courses are similar in kind, but perhaps less in degree.

A second advantage is what has been called "motivation," that is, a motive for each portion of theory developed may be drawn from one of the courses the student is taking, thus maintaining a vital interest in the work without going aside to introduce foreign material. That need for some such appeal to the interest of the technical student has been recognized is shown by the style of some of the recent textbooks in mathematics for technical schools. One may be permitted to express a doubt, however, as to the advantage of introducing technical material, out of its logical setting, into a theoretical course. Certainly the tendency to offer as motives specially devised uses of the theory under the guise of a practical example is indefensible.

As a third advantage, very closely related to the second, we may point to a fairly effective contact between the theoretical and technical courses without interruption of a reasonably logical and orderly development of each course. At least three methods appear to have been employed to accomplish this reaction between courses in institutions where the mathematics precedes the mechanics and technical courses. (1) Technical material has been introduced into the course in mathematics, in order to drill the student in the applications of mathematical principles. (2) Special courses in the applications of mathematics to mechanics, electricity, etc., follow the course in mathematics, either under the mathematics teachers or under the teachers of the other subject. (3) The teacher of the technical subject may treat portions of mathematical theory that he requires in his subject, as the need arises. Each of these three methods must involve repetition, sometimes with radically different methods, involving expense of time both of student and teacher. The first involves interruption of the systematic development of mathematics, and usually an improper and unintelligible presentation of the technical material. The third is likely to involve a disjointed presentation of the mathematical material, and a form of treatment difficult for the student to associate with previous

mathematical theory. This method can hardly fail to occasion undesirable delays and interruptions in the orderly presentation of the technical course. It is believed that the plan of carefully coördinated parallel courses reduces these objectionable features to a minimum.

Certain features of the system we have described were introduced in 1913–14, and the plan has been in operation, substantially as indicated, during 1914–15 and the present year. Changing conditions require modifications of details, and only the general features can be regarded as settled. The writer is convinced, even from the short experience, that the unavoidable conditions which compel the adoption of the plan of simultaneous courses in theoretical and technical subjects will prove a distinct advantage to the school.

We would not wish to be understood as advocating a plan such as we have here for adoption in institutions where other conditions prevail. We believe, however, that a course in mechanics might well run parallel with a part of the course in mathematics, preferably under the same departmental control. A three years' course in mathematics, say three hours per week, accompanied after the first year by a two or three hours' course in mechanics, and in the third year by technical courses, with proper attention to coördination, would seem to offer promise of overcoming many of the difficulties pertaining to the general problem.

A PROPOSED REORGANIZATION OF ENGINEERING INSTRUCTION IN THE FRESHMAN AND SOPHOMORE YEARS.

BY L. E. AKELEY,

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There are perhaps three considerations that would lead one seriously to consider some radical departure from the traditional presentation of the subject matter of a fundamental science like physics.

First: The so-called "sag" in the sophomore year.

Second: The transferability of the training obtained in physics to other fields of engineering.

Third: No very remarkable success is at present achieved in helping the student to become a thinker.

There are some advantages in the traditional way of presenting physics we should not care to lose. Whether or not the average student is helped to become a thinker, the student who masters the subject is compelled to be a thinker. The subject is presented as a coördinated body of knowledge requiring for its mastery continued effort in exact thinking. The only question is whether the kind of presentation employed furnishes the incentives for doing that which its mastery demands. In other words, physics may be appropriated by the student in a mechanical way. His mastery of the subject may be only apparent. He may have acquired very little power to think and may find it impossible to apply the principles of physics to the engineering field.

The objection always raised to one who proposes to increase the incentives to study is that the motive for the proposed change is the desire to make an inherently difficult matter illegitimately easy, to change a course that ought to afford

severe discipline into a snap. But the question at issue is in no sense one of hard work versus easy work. The question is simply this. Are we going to present a fundamental science in a way that respects the conditions under which the mind will function in a process of reasoning?

In the first paper* the principles underlying the proposed change in the courses in physics were outlined and based on the psychological laws that govern the reasoning process. The circumstances under which the human being will reason are that he encounters some difficulty that stands in the way of something he must do. The surmounting of this difficulty is his problem, one that appeals to his "felt need." Under no other conditions does the human animal ever reason. In our teaching, efficiency demands that we appreciate these conditions necessary to the reasoning process. The sophomore finds physics a difficulty that he must overcome. If this "must" is simply a matter of "getting by" the student will have gained little that is transferable to the solution of real problems of engineering. If each problem in the physics course has a fairly well-apprehended relation to a felt need of the student as a future engineer, a higher grade of efficiency is secured.

Of course, there is a theory that the student should realize that the course in physics is necessary to his future work, even if he can not see the necessity. He may and probably does have some sense of such a relation between physics and engineering. But such a vague sense of relationship is psychologically nil. The need that makes men think is a *felt* need, not one vicariously experienced and accepted on faith.

There are two important elements in the reasoning process. First a problem whose solution appeals to a felt need of a reasoning being. Second, is the technical equipment, the instrumentalities with which he attacks his problem. The first element, that of the "felt need," must be developed by organizing in his consciousness a coördinated group of ends and

* BULLETIN, June, 1915.

purposes. These ends are the incentives to vocational interests and choices. The second element is made up of a disciplinary training in logical, mathematical and experimental devices for solving the problem. The first element should have a logical and psychological priority to the second, and it must have some priority in time. The student must have the felt need before he can have any interest in the instrumentalities useful in satisfying it. The traditional presentation of physics subject matter puts instrumentalities before the felt need. It is an inversion of the psychological process that fails to produce mental dyspepsia only because the student is more or less capable of protecting himself from the bad methods of his instructor. The difficulty, the problem, should be uppermost in the thought of the student. The instrumentalities should be such, at first, as suggest themselves readily to his mind, or such as the instructor may quite easily suggest to him. After a few problems that have a vital relation to his purposes as an engineer have been solved, the interest thus developed will lead him to some appreciation of the need of more elaborate instrumentalities for the meeting of difficulties closely allied to those already overcome.

But it will be at once objected that an inspirational course of lectures intended to create an engineering interest in physics will be so exacting in its demands for time that there will be little opportunity left for the actual study of physics.

This objection calls attention to the fundamental character which any departure from prevailing methods must possess. The course cannot be split into two distinct portions, one an inspirational part, the other disciplinary; one setting up ends to be achieved, the other showing how these ends are to be achieved. But these two elements of the course must develop together. Every problem must have as its background a group of vocational or other purposes, well coördinated, a "hierarchy of ends." Every problem must not only have this background but every problem must itself contribute to the development of such a background of professional and scientific interest. This inspirational background that fur-

nishes the "felt need" that makes every problem a difficulty vital to the student, must itself be slowly built up by the problems that are presented. The inspirational and the disciplinary elements of the course must react upon each other continuously, and all the time the solution of these problems must be developing an ever growing technical equipment for the overcoming of more intricate difficulties. Such a technical equipment is now the conscious object of the traditional presentation of physics. In the proposed change it will become from the student's point of view merely a by-product of his activity in problem solving. But this by-product will be slowly assuming an interest of its own in the student's mind until at last he will become conscious that it is his most precious acquisition. The failure to appeal to and develop the broader interests of the student as a background to his work in physics is a serious matter if there is anything in the theory advanced in the article published in the BULLETIN, February, 1916, entitled "The Sag of the Second Year." The author says: "There may be a method of teaching engineering students that could bring out definitely the real relationship of the fundamentals to their special course. But I do say that this general training of the first and second year seems largely responsible for starting the train of thought that makes for a revolution in the first year man's soul and shows itself in the sag of the second year."

Another advantage of the proposed method is that in the putting every subject in physics in the form of a "problem," a difficulty to be overcome, and in giving the technical instrumentalities, logical, mathematical and otherwise, a subordinate position in the student's thought, the real spirit of science finds embodiment. Science has advanced in spite of the dogmatism of its votaries. And dogmatism is inevitably engendered when emphasis is placed on the elaboration of theories, of laws, of principles, of definitions. These all assume the appearance of finalities. Not so, when the interest in these is subordinated to that in real difficulties to be surmounted by using these instrumentalities. If a student is at all suscep-

tible to scientific faith he is distinctly discouraged in it by traditional methods. In the traditional presentation these instrumentalities appear as a vast elaborated system whose acquisition is a distinct burden. But when the emphasis is upon the vast array of practical and vitally important problems that a few simple and easily understood principles will readily solve, the latter take on the appearance of wonderful labor saving devices. Few are they who are trained to the successful use of theory and many are they whose success is handicapped by scientific dogmatism. A man who directs the research work in a large industry told me he would not have technical graduates in his research work. He preferred the Ph.D.'s of the universities. His objection was that the technical graduate would never admit that a thing could be done in any way except the one which he had been taught. His education was a finality. The university Ph.D. is by no means free from his own dogmatisms but they are not the kind the technical man has. The university man comes into the technical man's field free from the latter's dogmatisms. The traditional methods in education come from a time when the scientific spirit was unknown. The striking anomaly of our time is that science has found no better way of finding educational expression, a way that more or less effectively defeats her own ends.

A transfer of the student's training in physics to his more special engineering work will be facilitated by the fact that he first finds his " problems " in physics in the engineering field. In the traditional course in physics the whole subject has been analyzed into its elements. The student attacks one of these elements at a time. After a number of them have been mastered they are assembled into a logical whole. Another group of elements is then studied and then assembled together with the former group into a still larger group. The subject is built up out of its elements. The maxim "Divide et impera" is a good one. But all the advantage lies in the work of the strategist who looks after the "Divide." The student does not witness a process by which the subject was

broken up into its elements. He is expected to become interested in the mechanical assembly of the elements. This is the logical way. But logic should appear in the maturity of the reasoning process. It is only potentially present in the early stages. The psychological way is to begin not with elements but with wholes. The whole with which beginning is made is not a logically constituted whole. It is made up of human purposes and as the course goes on it will develop into a hierarchy of ends while the instrumentalities used in achieving these purposes will develop into a logical system. For example, the student is studying Ohm's law. In the background of his interest is the problem of the transmission of power over a distance with the most economic use of copper. This can readily be related to the whole group of ends which he as a prospective engineer has been lead earnestly to cherish. Into this background and closely related to Ohm's law are scientific interests as well as professional. This like other problems placed before the students is analyzed into its elements as in the traditional method. But the student does not begin with these elements. He begins with the whole of which they are a part, and he himself witnesses and takes part in the process by which this analysis is made and he also witnesses the process of extracting this particular problem from the larger engineering problem of which it is a part. He does not yet know the larger problem in its details. But he does see it as a whole and from it he abstracts the special problem whose details he proceeds to investigate. The whole subject of physics can be cast into the form of "problems" of this kind having a background of vital interests professional and scientific that the student can feel, problems that will challenge his best efforts, that will give him training and discipline and an ever growing stock of technical devices for achieving his professional ends. When the solution of a problem has been reached the student can be given a drill in the further application of the methods he has found useful. But this drill in methods of attack, in definitions, in demonstrations, in the more accurate determination of constants, in an

enlarged view of mathematical and experimental devices, in fact, in the whole scientific and logical paraphernalia of his work, comes after the material used in it as drill has become a part of the student's experience in the solution of vital problems. The student first finds his physics in the engineering field. It is the most natural thing for him to return from his physics to the engineering field. He begins in engineering and he ends in engineering. Every time he completes this circuit, his scientific interests have deepened, his resources for attacking problems have been enriched. The study of physics is not a preparation for engineering. Physics is an ever growing interest that deepens with his progress as an engineer.

The whole subject matter of physics may then be divided into units of instruction. Each unit is organized around a "problem." By problem is meant the formulation of a proposition involving an engineering or scientific achievement, one that appeals to the interest of the student. This proposition is definitely related to the whole group of ends which his vocational interests embody. This problem is chosen in such a way that it may be successfully attacked by a technique which does not require so much preliminary elaboration that the student forgets the "problem" itself.

After the problem has been solved the method used in solving it is applied to as large a field as possible, giving the student a thorough drill in discussion and in laboratory exercise. The following are the elements into which each unit of instruction is divided:

1. Background covered by a lecture opening up the engineering field and its problems.
2. Selection of a definite problem in this field, a problem central to the whole field and distinctly and vitally related to the ultimate end of an engineering education.
3. The choosing of a technique for the attack of this problem.
4. The solution.
5. The wider application of the same technique in discussion and in laboratory.

6. Deduction of laws, principles and statement of definitions.

If all that has been stated above were accepted there would still be much diversity among teachers in the organization of these units of instruction. Such diversity would be an advantage adapting instruction to the needs of different classes of students. The background of interests might in many cases be more purely scientific in character, in other cases more professional and vocational.

I shall now outline the first unit of instruction which I believe adaptable to any class of students.

1. Background—The transmission and distribution of power.
2. Problem—How may power be transmitted over long distances with permissible losses with the most economic use of copper?
3. Technique—The use of the current measurer.
4. Determination of the distribution of electrical utility on a transmission and distributing system.
5. The application of this technique to the distribution of currents in branching circuits, measurement of resistance, of electromotive force in batteries and thermoelectric couples, the study of a large variety of current measurers.
6. Preliminary definition of current, resistance, electromotive force, electrical quantity, watts as a measure of electrical utility.

I am perfectly aware that such an organization of the first unit of instruction in engineering college physics will not be considered at all feasible on first view. To make it feasible certainly requires the solution of some difficult educational problems. I believe the following statements will demonstrate that these difficulties may be readily overcome and this unit as above organized be shown to be eminently feasible.

Power development and power transmission constitute a comprehensive engineering problem. Power transmission is a central feature of this problem. It is a problem that appeals to the imagination. Long distance transmission problems involve the greatest and most epoch making developments of engineering. In the history of electrical engineering for dec-

ades the distance over which power could be transmitted was limited by the amount of copper demanded. The copper problem as above stated is therefore central to the whole problem. This does not mean that we are going to attack at the beginning the whole highly technical question of a transmission line. But it does mean that many features of transmission line problems are going to be in the background of the student's thought and some of them are going to be reached early in the course. Such problems will not be presented in all their technical details. Certain features of these problems will be isolated. But the student will feel the ultimate bearing of his earliest work. Preliminary to any such measurement of power loss on a line in power transmission it will appeal to the student as a matter of fundamental interest to find a reliable way of measuring electrical phenomena. The very idea of measuring such phenomena appeals to a very strong scientific interest. It appeals to curiosity, and to the emotion of wonder. The student has already acquired the popular conception of electricity as a current. There is no call to treat this concept at all critically at this point. Assuming that there is such a thing in a live wire as to justify the use of the word current in relation to it, raise the question whether there be any practical way of measuring it. It is not at all necessary at this point to understand the internal structure of a "current measurer." The only question is what will such an instrument actually do? Take a two-wire insulated cable. Take it so long that the resistance of the wires of the cable is large compared with that of the current measurer. This precaution is for the instructor. Put this double wire into a circuit allowing the current to divide between the two branches. Now these two wires are alike so far as two wires can be made so. They are of the same diameter and length. The error in this assumption may be shown to be very small. Now if there be such a thing as a current flowing in the live wire, that current could not be conceived of as dividing in any way other than equally between the two branches. Now the scale of this instrument is

marked in divisions numbered 1, 2, 3, etc. Now the only requirement for a current measurer is that these numbers should be proportional to the current flowing through the instrument. Now if the instrument be switched first into one branch and then into the other, and, then, if it should read the same in one branch as in the other, and if it should read one half as much in each branch as it reads in the main line, and if this ratio should be maintained no matter what currents were made to flow in the main circuit within the limits of the instrument's capacity, we would conclude that this instrument indicates by its readings the relative values of current flowing through it. It is a current measurer. This instrument now becomes the means without further ado or any more theory, for the solution of some interesting and significant problems. Such a problem will naturally suggest itself at once, viz., how may one control the distribution of current in a wiring system. The current carries certain utilities in the way of heating, lighting and motive power. Here we have in this current measurer the means of investigating the distribution of these utilities. To this end make another branching circuit where one branch is double the length of the other and the diameter of the wires is the same. Make other branchings where the lengths are the same and the diameters are different. That property of wires which determines how currents will divide may be given the name either of conductivity or resistance. A wire that carries one half as much current as another wire parallel to it is said to have double the resistance of the first. Now it is perfectly possible to choose at this point an arbitrary unit of resistance but one that shall be very approximately the ohm. Define this unit as that of a piece of copper wire of definite length and diameter and temperature. The experiments above outlined will readily give the law that governs the relation of resistance to length and diameter. By keeping all currents far below the carrying capacity of the wires the question of temperature need not be considered at this point. The same experiments will also show that in a branching circuit the product of current mul-

tiplied by resistance is the same in each parallel branch. This constant product may also be named. It may be called a certain voltage. Of course it is assumed that the instructor has chosen for current measurer an instrument that is a fairly accurate ammeter. The definition of voltage at the outset will be $V = CR$. There is no need and no possibility of introducing at this point the concept of potential. The student will add new content to this concept of voltage as his work progresses. There is no necessity for final definitions at the start. All concepts grow with human experience. The only alternative to this proposition is a deductive and dogmatic teaching of science, which is nothing less than a contradiction of terms.

This product $C \times R$ found constant in any number of parallel branching circuits may be used for a more complete control and understanding of the problem of distributing electric utilities. In the first place current measurers covering a current range from 25 amperes to one milli-ampere can be tested by the method described above and the student may be satisfied of the reality of this range of current measurement. These current measurers may then be used in a rough verification of the accuracy of resistances. All this work will give laboratory exercise. Then a milli-ammeter is connected up with a large resistance in series with it. This instrument with its resistance connected across any two points in a circuit forms a branching circuit and the millameter reading multiplied by the resistance in series with it gives the value of the product CR for every other branch parallel with it. We will call this product the voltage of this group of branches, without more accurate definition at present. This instrument with its series resistance is called a voltmeter and the student is introduced to other instruments whose scales read the product $C \times R$ directly in volts. The student now has two instruments with which to investigate the electric circuit, the ammeter and the voltmeter. He knows that each is a current measurer. He soon finds that they enable him to study the distribution of electric utilities in a circuit. He finds that the

voltmeter readings are proportional to the number of lamps fed in series, or the number of electric heaters or other appliances in series and that the ammeter will at the same time give readings proportional to the number of such utensils fed in parallel. The total utility obtained is seen to be proportional to the product of the voltmeter by the ammeter reading. The "problem" of this "instructional unit" may now be attacked. In order to transmit a certain quantity of electrical utility measured as a product of current by voltage with only a certain permissible loss how much copper must be used? The student will see that the solution of this problem depends on the voltage used. A new problem is thus opened up for later investigation, viz., the production of high voltages. The problem of copper expense for the voltages in current use may be solved at once. The methods that have been used in the solution of this problem may now be applied to measurement of resistance by the Wheatstone method. The potentiometer may be introduced at this point. The use of the potentiometer will give an additional interpretation to "voltage." The student finds that the voltage of a cell is something that may prevent a current flowing through the branch in which the cell is placed while the same voltage in the branch in parallel with the cell is proportional to the resistance through which the current is driven and proportional to the current that is driven. The idea of voltage as an electromotive force is thus given. But now electromotive force means to him that which resists the current in the case of the cell and drives the current in the branch parallel to the cell. While the student's interest in current measuring is active let him become acquainted with a variety of current measurers. Take a milli-ameter shunted across a low resistance and test the whole combination as a current measurer by rapidly switching it into one of two equal branches and then into the main line. Use a D'Arsonval galvanometer shunted across a low resistance with a high resistance in series, as a current measurer. At this point the student may be lead to see that the galvanometer is a current measurer by virtue of

the fact that a wire carrying a current in a uniform magnetic field is deflected by a force proportional to the current. He sees that the deflections are proportional to the measured current as long as the coil does not swing out of the field and he may be shown that these deflections are proportional to the torsional force of the suspending wire. Then a tangent galvanometer may be mounted up in the laboratory by putting up a circular frame in proper position relative to a suspended needle. This may be tested as a current measurer just as the others were. But this test will give a new content to the student's concept of current. Let different sections of a long circuit be coiled about the frame using the same number of turns each time and keeping the distance relations between coil and needle the same. It will be found that current is everywhere the same in every section of a long undivided circuit, no matter whether near or remote from the battery, no matter whether the wire of a given section be heavy or light. Then raise the question of two distinct concepts of current, *i. e.*, current as swiftness of motion in a river and current as the quantity of water that passes a section per unit of time. Show that this latter definition is the one that must be applied to the electric current by virtue of the result obtained in this tangent galvanometer experiment which shows that the current is the same in every section of the circuit regardless of the dimensions or other character of the conducting wire. Now current may be defined as $C = \frac{q}{t}$. This "unit of the instruction" may not be left until the student is familiar with the methods of verifying the accuracy of ammeters and voltmeters by comparison with standard cell and resistances. A special section may be made for those members of the class who want to carry on considerable practical work made possible by the instruction given under this unit. A class made up of both engineering students and medical students, arts students, could be divided into sections to pursue work adapted to their special interests until the next unit is taken up.

At the beginning of the work in current measurement no questions were raised about the internal construction of the current measurer. The only question was what can be *done* with one and how may we know it is a current measurer. At the close of this unit the question of the construction of current measurers may be taken up. The whole field of electrodynamics is opened up, not with a view to a thorough treatment but in order to give a background for the "problems" that are to follow in both electricity and mechanics. The student's reach is kept broader than his grasp.

The whole subject of physics will be divided into units of instruction having features like the one outlined above. Every unit centers about a "problem." The unit and the problem are so selected as to keep the student conscious of his place on the engineering map. The problem is one that stands in a prominent relation to his own vocational interest in engineering and it is one that is contributing to the building up of that interest in the student's consciousness. The above unit is chosen as the first one because it is central in interest and because it can be attacked by a very simple and easily mastered technique.

TECHNICAL BOOK WRITING.

(Part II.)

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After the topics of the chapters have been arranged in proper sequence, and after all the rules and regulations concerning the preparation of the MS. have been formulated and recorded, the next step to take is to begin writing. In many cases it may be best to start with Chapter I and write consecutively until the last chapter is finished, but often something occurs which prevents such a systematic manner of action. It is possible that certain investigations, mathematical or otherwise, have to be made before a certain chapter or certain chapters can be written; and in such cases it is perfectly legitimate to write scattered chapters and assemble them later. The main objection to this method is that the writer is apt to forget the proper sequence and refer to something which is contained in a subsequent chapter as if it had appeared in a preceding one, simply because it had been written out of turn. Care should be exercised so as to see that no such *faux pas* is made. If one is writing continuously with-but interference from outside affairs, he may be able to carry the correct sequence in his mind; but if the composition is done from time to time in the midst of other work, he will forget not only what he has already written, as distinguished from what it was his intention to write later, but also the order in which the various topics already dealt with occur. Certainly, it is better to write continuously; but a busy engineer will never find an opportunity to do so for any great length of time, hence the burden of the work unavoidably will be

greatly increased. In writing "Bridge Engineering," the author had to do the work spasmodically, sometimes with intervals of months and even of years; and each time he recommenced, it took him two or three days to get into full swing; for he had to read much of what was already written so as to have his mind "saturated" with the general subject and its ramifications, and in order to become again acquainted with the established sequence of treatment for the book as a whole.

Sometimes it is well to draft the preface before commencing to write the chapters so as to have a guide to refer to for keeping the writer on the proper track; but if this is done, it will be found necessary practically to rewrite it after the book is otherwise finished, because the dating of the preface should be made as late as possible, and because its contents should be strictly in accord with the text, which could not be the case if the final writing was done in advance thereof. A comparison of the preliminary draft with the final writing of the preface will give a good indication of how the writer changed his ideas as to the contents and scope of the work during its actual preparation.

The title page should be prepared about the time that the preface is finally written; and it should contain a full statement of its author's degrees, distinctions, and technical societies—also, if he so desire, a list of his other principal technical books, in case he has been guilty of writing any.

As early as possible there should be prepared a list of illustrations and a list of tables for each chapter. Of course, this has to be tentative, because the necessity for illustration will become apparent as the chapter is evolved. For financial reasons the number of figures should be held down to the minimum that is compatible with thorough explanation of the text; but in case of doubt it is best to illustrate. Again, tabular matter is expensive to put in type, hence all unnecessary tables should be omitted. As was stated previously, diagrams, for convenience in using, are generally preferable to tables; but they cost more to produce. The best method of number-

ing figures and tables has already been treated, as has also that of their titling. In the author's opinion, it pays a writer to prepare the drawings for the cuts and to oversee the manufacture of the etchings; for then he can have all the work done exactly as he desires, and, if there are any mistakes made, he can have them corrected. While zinc etchings are not expensive *per se*, the preparation of the drawings from which they are made is quite costly. One would say at first thought that it is an easy matter to photograph old tracings for the preparation of the plates, but that can seldom be done, because the lettering on them is too small. They have to be retraced, and the lettering has to be made of such dimensions that when reduced by the photographing it will be of just the right size for the book. On this account different drawings require different sizes of lettering—and sometimes also different weights of lining. As in "Bridge Engineering" there was to be a large number of cross-section diagrams, the author gave considerable attention to the determination of the best manner of preparing them. After a thorough investigation, it was decided to make a very carefully ruled wax plate ten inches wide by fifteen inches deep divided into one-inch squares by comparatively heavy lines, and redivided in both directions by somewhat lighter lines into half-inches, and by still lighter lines into tenths of inches. Impressions were taken from this plate on Reynold's Two-ply Bristol Board, the sheets being of Demy size 14⅝ inches wide by 18¼ inches long. These white sheets, being exceedingly smooth, gave very clear impressions with uniform lines; and it was practicable to draw on them curves and lettering which when photographed down produced very satisfactory zinc etchings. A reduction to half size or a trifle less was found to be most satisfactory. It is true that the best of zinc etchings do not give quite as good prints as plates made by the wax process, but they cost less, and they are likely to be more accurate; because one is at the mercy of the wax engraver, who can draft the curves more or less as he wills, leaving the author of the book practically powerless to prevent inaccuracies, while the

copy for the zinc etchings can be prepared directly under the writer's supervision, or, if need be, by himself personally.

The preparation of the drawings for the illustrations should be carried along with the writing of the text so that the cuts may be completed and ready for the printer by the time that the galley proof is corrected; but care should be taken not to start any drawing or diagram until it is known beyond the peradventure of a doubt exactly what it is to contain. Corrections on such drawings are liable to cause blurs or slight defects in the cuts, besides being costly to make.

After a chapter has been written by hand, it should be checked carefully by the writer and corrected for punctuation, spelling, sentencing, and paragraphing, and also for omissions or duplications; and it would be good policy to pass it over afterwards to a capable assistant for his comment in respect to the same particulars. If it contain any mathematical work, or any new theory proposed by the writer, or anything unusual or in any way out of the common, the same should be subject to a rigid analysis and comment by one or more assistants who are capable of doing such criticism thoroughly and effectively. This checking should be attended to at as early a date as practicable; because, if the work contain any errors, their effects are likely to be carried on to succeeding chapters.

As the work of writing progresses, the completed parts should be read carefully by both the writer and one of his assistants so as to make sure that there is nowhere any unnecessary duplication of treatment of any subject. If this can be done in the handwritten work, so much the better; but if not, it should be attended to in the typewritten work. The sooner that unnecessary duplications are removed from the text the better; but it is undeniable that this can be accomplished with less effort by dealing with the typed chapters.

The question of what is and what is not legitimate duplication or repetition throughout the book is a difficult one to decide. If there are chapters on specifications and chapters that involve dissertation concerning matters treated in the

said specifications, duplication is eminently proper; and no apology therefor or notice thereof is necessary. Again, the same subject may be treated in different chapters from different points of view, and here, too, repetition is unavoidable; but it is advisable to indicate unobtrusively that the writer recognizes the duplication. This can be done in several ways, generally by saying "as mentioned in Chapter —," or "as previously pointed out," or "as was stated in a previous chapter." Once in a great while, for the sake of emphasis, it becomes necessary to repeat a statement in the same chapter, and in such a case it is absolutely essential that an acknowledgment of the repetition be made, and preferably an apology therefor. Any unrecognized duplication anywhere in the book, barring only the previously mentioned case of specifications and dissertation concerning the topics they cover, is a detriment to the treatise; for it gives the reader the impression that the writer was careless.

The handwritten pages should be so numbered and annotated that the typewriter will have no reason for making any error in the copying, in spite of all the alterations, insertions, omissions, and corrections that may have been made, and especially in respect to correct sequence. For instance, when writing an insertion on the back of a page, it may prove to be so much longer than was at first contemplated that there is not sufficient room for it, necessitating an additional page or pages. In that case one should write with red pencil at the foot of the back of the page, which for illustration may be assumed to be numbered 49, a direction to "Pass to p. 49*A*," and at the top of the new page there should be written "Contin. from back of p. 49." If the insertion is so long as to require an additional page, there should be written in red at the foot of p. 49*A* "Pass to p. 49*B*," and at the top of p. 49*B*, also in red, "Contin. from p. 49*A*." Should, however, the writer recognize at the outset that the insertion is going to be a long one, he should mark in red at the proper place "Insert p. 49*A*" or "Insert p. 49*A et seq.*" All notes for the benefit of the typewriter should be written with a red pencil so

as to make it apparent that they are not to be copied—for instance, the word "over," meaning to pass to the back of the sheet.

In preparing the MS., all kinds of labor-saving and time-saving devices should be employed, such as pencils with rubbers on their ends and pencil sharpeners; and all work should be done in proper sequence so as to avoid the possibility of having to do parts of it more than once. There is a time-and-trouble-saving feature of a passive nature which might be worthy of mention, viz., that it is best to avoid all cross-referencing by page numbers, although it must be confessed that such direct references are a convenience to the reader. If such a system of referencing be adopted, the work of the printer will be greatly retarded, because it will be necessary to await the finishing of the last of the page proof of the entire book before beginning to start filling the blanks left for the page numbers. Again, this system would probably involve an extra reading of the whole of the page proof. Under ordinary conditions it will suffice to refer to the chapter instead of the page; and, if any trouble in finding the place be experienced, either the index or the table of contents will locate it readily. If any chapter consist essentially of specifications, the clauses thereof are numbered; and in that case the reference can be made to the proper clause number. As was before indicated, it is advisable to place at the end of each specification-chapter a special clause-index to facilitate the use of the specifications in designing and construction.

After all the work previously mentioned has been completed, the MS. is ready to hand to the typewriter for copying onto letter-size paper of good quality with double spacing so as to permit of corrections and interlineations. Margins of one inch at the left-hand side, an inch and a half at the top, and three quarters of an inch at the bottom of the paper should be left. Each page should be numbered at the middle of the bottom margin; and near the upper left-hand corner or some other convenient place there should be marked with a rubber stamp the number of the chapter, so that in case of the sheets

of different chapters becoming mixed they may be readily assorted.

The typewriter should do all the copying with the utmost care, making always an original and two carbons. The fewer errors of typing there are the less trouble will there be in correcting the carbons. All the punctuation, capitalization, quotation marks, italicization, insetting, and paragraphing of the MS. should be closely followed, unless, of course, it be apparent that a mistake has been committed, in which case the writer's attention should be called thereto. In typing, distinction should be made in the lengths of hyphens and dashes; and if the machine does not possess a dash type, two connected hyphens should be used instead. In dividing words at the ends of lines, care should be taken to stop at the end of a syllable, and never to make the first syllable of less than three letters in length or to carry over an "ed" at the end of a verb. Rather than to violate these rules, it is better to let the right-hand side of the page have a ragged appearance.

As soon as a chapter is typed, the typewritten work should be checked against the MS. by two persons, one reading from the latter and the other following with the former and making any necessary corrections. This ensures that everything is in proper order and that nothing has been omitted, besides locating most of the typographical errors. The reader should call off all punctuation marks, intermediate capitals, italics, and paragraphs as he reads; but generally he need not concern himself with the hyphenization. Each checker should use for marking corrections on the typewritten pages of the first impression (the one which should always be the first corrected) a colored pencil which is of the color specially allotted to his personal work, so that the individual responsibility for all corrections can be determined at any time beyond any doubt. This may prove quite convenient at times; and the restriction of each man to using a certain colored pencil can cause very little trouble.

Next, the writer himself should go over the typewritten work alone, checking it for all minor errors or omissions,

making any improvements in diction that he thinks advisable, changing sentence-lengths and paragraphs if he deems best, marking on the margin the name of any special kinds of type he may desire used for different parts, locating the places where he thinks it best to insert the various figures and tables (unless the latter be already copied into the text), and determining finally concerning capitalization, hyphenization, italicization, and indentation. He should also indicate the styles of type desired for all headings and subheadings. In doing all this he should be both methodical and consistent, using the same method for all chapters, and employing type of less and less size or prominence in passing from major headings to minor headings and thence to subheadings. Distinctive type is generally better than close spacing of the regular type for the purpose of signalizing quotations, but the latter method might be adopted when making extracts from the writer's own published works. Wherever close spacing is required, it should be so indicated plainly on the margin of the MS. It is understood, of course, that the exact location for figures and tables must be left to the printer, who is supposed to follow the writer's preference as nearly as he can.

When one reads in the typed pages what he has written and corrected by hand, he will be almost sure to see needed modifications or additions which were not apparent to him in the hand-written work. As before indicated, such changes should be made in such a manner as not to let it be discoverable that they were afterthoughts. This is entirely feasible after one has had some practice in the making of such modifications. If any of these can in any way change statements that were made in other chapters, all such chapters should be carefully revised accordingly, so that there may be no contradictions anywhere in the book. Similarly, if, for any reason, any portion of the text be cut out, there should be no hiatus left, and the elision should not be allowed to affect injuriously any other portion of the book. In a large treatise where some of the chapters are very closely allied—for in-

stance, those of specifications and those of the corresponding description—this avoidance of conflict is by no means an easy task; and to ensure its proper accomplishment the writer should carry in his mind the entire contents of each completed chapter and, as nearly as may be, what he intends to put in the as-yet-unwritten chapters. This work of ensuring harmony throughout the book should be done *at once* whenever a change is made; and if that be impracticable, a note should be recorded in some conspicuous place to the effect that it is still to be done. Moreover, it should be attended to at the very first opportunity; because, otherwise, the idea of the change and its consequences will become less clear in the mind, and the modifications will not be effected satisfactorily.

It was mentioned that there should be made three typewritten copies of the MS., but no reason for this was given. The original should go to the printer, the first carbon should be kept by the writer, and the other should be filed in some safe place in another office as a precaution against fire or loss in transit. This precaution will probably prove to be unnecessary; but if not, it will save much time and trouble. It is possible, too, that some copies of one or more chapters may be mislaid; and in that case the third set would prove to be a time saver. Its only disadvantages are the extra cost for paper wasted, the lost time in making corrections of errors, and the trouble of preparing and taking care of the third file.

Whenever the writer or one of his assistants checks the first impression of a typed chapter, he should mark it on the upper right-hand corner of the first page thus—"Checked by R.C.B. 10/25/15"—giving the initials of the checker and the date of checking; and if any rechecking is done, it should be marked "Rechecked by etc." As soon as the first impression of any chapter is finally checked, the second and third impressions (first and second carbons) should be corrected to agree therewith; and they should be marked in the upper right hand corner thus—"Corrected by N.E.W. 11/3/15," giving the initials of the corrector and the date of making the correction.

If, later, any additions are to be made to the chapter or

any corrections of more than three or four lines, they should be typed on the usual paper with at least an inch of margin both above and below for pasting; and after these are duly corrected, they should be inserted in the typewritten text, taking care to make the order of the impressions in the corrections agree with that of the main text. There should be no delay in the insertion of these corrections, for it might cause trouble by interfering with the proper progress of the writing. It may be troublesome to attach the corrections to the third copy because of its being located in another building; but if the insurance afforded by this precaution is to be effective, the corrections for the said third copy should certainly be inserted therein. In the case of a short correction, it will suffice to erase a few lines and to write it in by hand; and this should be done in all three copies.

When any typewritten chapters or portions thereof are rewritten and corrected, the abandoned work should, preferably, be destroyed, or else it should be marked plainly in red "VOID" and filed away where it cannot possibly become mixed up with the rest of the MS. The importance of this suggestion may not be recognized until after some such abandoned work has caused a lot of confusion and loss of time. The author, as a rule, is averse to destroying any papers that may be needed for reference; hence he advises that there be separate files for the handwritten chapters, the typewritten ones, the galley proof, and the page proof, and that these be maintained until after the book is issued—in fact the corrected page proof should be held until the entire finished book has been checked against it so as to make sure that all the final corrections which were left to the printer to insert and check have been correctly made without involving any new errors. Any corrections found necessary by this checking, would, of course, have to be made in the electrotypes.

As soon as practicable after the list of items for the various chapters has been prepared, the size of page, the size of book,

and the number of volumes should be finally determined; for unless this be done, the sizes of plates for the illustrations cannot be settled, and hence the work on the cuts cannot proceed. Moreover, it is well to decide as soon as possible upon the quality of paper and the style of binding, also upon what printing should appear on the cover and where it should be placed.

Before the MS. is sent to the printer, it is advisable that the writer give it a final reading so as to make sure that there are no errors nor omissions, that the punctuation is correct, and that full instructions have been given concerning the setting of the type. This check will require time; but it certainly will be time well spent.

With the MS. there should be sent a letter to the publishers describing in full detail how the writer desires the printing to be done, stating the number of copies of galley proof and of page proof required, noting how the figures and tables are to be inserted, giving the size of the printed page, telling how the running heads are to be made and how the page numbers and chapter numbers are to be recorded, instructing concerning the various kinds of type and type-spacing to be used and where each kind of type is to be employed, and giving full information about punctuation, hyphenizing, spelling, capitalization, abbreviations, paragraphing, numbering of figures and tables, designation of equations, italicization of mathematical symbols, and either the italicization or the enclosing in quotation marks of the names of books and periodicals. Under ordinary conditions two copies of galley proof and two of page proof will be required, but special conditions might arise calling for three copies of each. The name of the book and the number of the chapter should be printed at the top of the left-hand page, and the title of the chapter at the top of the right-hand page. The page number should be placed at the upper left-hand corner of each left-hand page, and at the upper right-hand corner of each right-hand page, excepting only that for the first page of each chapter the num-

ber is to be inserted at the middle of the bottom, and that where a cut or cuts occupy an entire page no numbering thereof will be needed. The printer should be furnished with a copy of the list of doubly-spelled words that was prepared for the office force, and to the adopted style of which they were instructed to adhere. As mentioned incidentally before, some method should be adopted and strictly followed as to italicization or enclosing in quotation marks of the names of books and periodicals. Either method is both customary and correct; but the use of the two indiscriminately is inadvisable from the points of view of uniformity and good taste. While the adopted system should be adhered to in the preparation of both the handwritten and the typed chapters, for fear of infractions of the rule having inadvertently been made the printer should be instructed to follow it in preference to the MS.

While it is certainly best for several reasons to furnish the printer with the MS. continuously, beginning with Chapter I, it may save time to send it to him irregularly in sections as fast as it is completed. The latter method is the one which the author found it necessary to adopt in the case of "Bridge Engineering," and it caused no serious inconvenience to either the publishers or himself, yet at times he had occasion to wish that the work had been sent out continuously so that it might come back in the same manner.

There should be an understanding between the printer and the writer as to what system of symbols for proof correction should be adopted. If the printer prefer to use his own, he should send a copy of it to the writer; but otherwise the system given in Frost's "Good Engineering Literature" could advantageously be employed.

As soon as the galley proof begins to come in from the printer, it should be checked against the MS. by two men, one reading from the latter and the other correcting the former. As in the case of checking the typwriting, the reader should indicate by naming them all punctuation marks, capitals,

italics, brackets, and paragraphs; and the listener should mark both in the text and on the margin, according to the standard method, all the necessary corrections. If the printer has found any errors in the MS. and has corrected them, his corrections should stand; but if he has made changes to suit his own notions of what is proper, and if those notions do not agree with the ideas of the writer, the changes thus made should be corrected. This check ensures that none of the text has been omitted and that, in general, the corrected galley agrees with the MS.

Next, the writer himself should go over the corrected galley to make any corrections that have escaped the eye of the first checker and to effect minor improvements in punctuation and sentencing. If he sees that any changes in the text are really and truly necessary, he should make them; for, strictly speaking, this ought to be his last opportunity to do so. It is true that he will still have another chance to make corrections in the page proof, but such corrections are either closely restricted or else very troublesome and expensive. As before pointed out, the earlier in action the text reaches its final shape the better in every way will it be for all concerned; but that is no reason for failure to correct errors or to make truly necessary additions.

A single reading of the galley by the writer is generally not sufficient, because he has too many kinds of important things to carry in his mind simultaneously for correction; for instance, first, punctuation, spelling, syllabification, hyphenization, etc.; second, the thought contained in the text; and, third, the polishing of the diction. He should either read the galley a second time or else turn it over to an assistant for a careful check—or, better, both! The more checks the less the chance of error but the greater the expense. All the galley of "Bridge Engineering" received first a check by the printers, then two readings by the author and his assistants; and, moreover, most of the text was given still another complete reading in the page proof. With all these checks, and in

spite of extreme care, it is likely that some typographical errors will be found in the book; for proof-reading is uninteresting work that is very conducive to somnolence, and it certainly requires a specially keen and active state of mind to do it properly. Care should be taken to see that all illustrations have been provisionally located as well as possible and that none have been overlooked.

After a bunch of galley proof has been finally checked and corrected, the second copy sent by the printer should be brought to exact agreement with it and filed away. The necessity for this extra copy is two-fold; first, to provide against loss of the first copy in transit; and, second, for use in the writer's office before the copy first corrected comes back with the page proof.

By the time that the corrected galley is ready to return to the printer, the cuts pertaining thereto should also be ready. Each cut should have its number distinctly and indelibly marked upon its back; and proofs of them all with the numbers and titles properly placed and written should be made and sent to the printer simultaneously with the corrected galley.

All MS., corrected galley, and corrected page proof sent to the printer should be forwarded by express with large insurance, because a loss of any of it might involve great expense and waste of time; besides, a high insurance makes the carrier more careful, and the expense of insuring is small.

A thorough system of filing for all the MS. (both handwritten and typed), the corrected galley, and the corrected page proof in the end is a time-and-money saver, and it certainly should be installed.

After the printer receives the corrected galley for several of the early chapters, he begins to make up the page proof and to send it to the writer in comparatively small amounts, together with the corresponding corrected galley. The writer then must see to the following:

A. That all the corrections indicated on the galley have been correctly made.

B. That in making the corrections no new errors were introduced.

C. That the running heads of the various chapters are satisfactory, and that there are no mistakes in their typography.

D. That all the pages are correctly numbered.

E. That the chapter number is properly inserted at the upper right-hand corner of each left-hand page.

F. That all figures and tables are satisfactorily located.

G. That the numbering and titling of all figures and tables are correctly done, that the proper type is used therefor, and that they contain no typographical errors.

H. That the text is properly continuous from page to page.

I. That all references which were previously left blank are duly filled out.

Next it is generally necessary, or at least advisable as a matter of precaution, to have someone give the corrected page proof an independent reading so as to look out for more errors of an incidental nature, such as those caused by the dropping of type and resetting it, also for mistakes that may have escaped notice during all previous readings of the text. It is well to have this check made by an assistant, because by this time the writer will have become so sick-and-tired of the whole business that he may not be able properly to concentrate his mind on the task.

If there are any uncorrected errors in the page proof, or if any new ones have been made, or if any changes are absolutely necessary, they should be so indicated in both the text and the margin, then a copy of all the corrections should be made on the duplicate page proof, after which it should be properly filed. Corrections, if at all possible, should be so made that the paging is not disturbed. Next the original page proof should be sent in small amounts, as fast as corrected, to the printer for further correction, if necessary; and, if the mistakes be numerous, it will be prudent to call for a revise. If the typesetting be done by the linotype method, it will be necessary to take special care in searching for new

errors both preceding and following the correction, carrying the check both ways far enough to reach undisturbed type; but if the monotype method be employed, the chance of new errors entering is materially reduced. In the author's opinion, the linotype method is the curse of the book writer. For years it has been to him a source of intense annoyance, because at times it has almost seemed that for each error corrected two new ones were made.

It is said that even if one gets the page proof absolutely perfect, errors are liable to creep into the electrotyped work, mainly by the sinking of an occasional word or letter or by the rising of the sides of the boxed type; but the publishers deny this. In the case of "Bridge Engineering" the author was persuaded to run the risk of mistakes being made in the electrotypes; and in so doing he certainly made a mistake, for there exist in the book a number of minor errors that were not in the page proof. These were undoubtedly caused by the accidental dropping of some of the type and the careless resetting and checking of the replaced portions. The author has only himself to blame for trusting to the printers to make proper electrotypes; because his friend, Dean Milo S. Ketchum, had warned him against the possibility of errors being made in that way. The reason why he took the risk was because the book was already greatly delayed. In any future work he will certainly check thoroughly a full set of proofs made from the electrotyped pages.

The preparation of the table of contents can best be done from the corrected page proof, provided that this will not involve too much delay; otherwise it can be handled from the galley or even from the typed MS., leaving blanks, of course, for the page numbers to be filled in later. The work of preparing the synopsis of contents of each chapter has to be done methodically and systematically after due deliberation. The headings should be short, concise, and explanatory. There should be enough of them to give the reader a clear idea of

what the chapter contains but not so many as to discourage him from perusing the list.

Similarly, the lists of illustrations and the list of tables can best be prepared after the page proof is nearly finished, for these will require the page numbers to make them complete. The illustrations may either be included in a single list or divided into two or three lists according to their character. In "Bridge Engineering" there are three, viz., one for ordinary figures, one for cross-section diagrams, and one for views. The object of the division is to lesson the labor of the reader when searching for an illustration that he has seen before and desires to use.

The last thing to be done in connection with writing the book is the preparation of the index; and the time to do it is immediately after each consignment of corrected page proof has been returned to the printer. By following this method, the MS. of the index will be ready a few days after the last of the page proof has been corrected. Before starting to prepare an index, one should invariably read what Frost has to say upon the subject in Chapter XIX of "Good Engineering Literature," no matter how many times he may have read it before. What Frost there says is based upon a well-deserved roasting which *Engineering News* gave the author in 1898 for his failure to understand the true inwardness of the art of indexing when he prepared the index of his "De Pontibus." The lesson was a good one, and he has benefited by it ever since when indexing his various writings. The method that he followed in indexing "Bridge Engineering" was to dictate all the items to his stenographer, who then typed them on sheets of specially prepared gummed paper perforated horizontally at intervals of three quarters of an inch. Then he corrected these typed sheets and set them aside. For a portion of the work, however, owing to absence from the office, he had to write the items by hand and send them to the stenographer to copy, after which they were checked and corrected by his assistants. In order to save time, the stenographer occa-

tionally tore off the items and assorted them alphabetically into twenty-six groups. This was an unfortunate step, however, causing loss of time instead of gain; for by some mischance the items for six of the chapters were left in a drawer, and their omission was not discovered until after the MS. of the index had been forwarded to the printer. It was, consequently, necessary to arrange the omitted items alphabetically in the same manner as for an independent index, and express the sheets to the publishers with a request that all of the said items be properly inserted in the MS. previously forwarded before starting the typesetting. It would have been far better to wait until the completion of the typewriting of the entire index before doing any tearing, so as to arrange the sheets in the order of the page numbers and thus make sure that none of them had been omitted.

The method of checking the typed index-slips involved three readings thereof; first, for typographical errors, punctuation, and spelling; second, for evident errors in page numbering; and, third, to cut out any useless headings that might have been unintentionally included.

The manner adopted for arranging the items was to pass over the sheets to several assistants, each of whom tore them into strips and assorted these by their first letters into twenty-six groups; then the several sets of groups were combined into twenty-six main groups. Next, each assistant took as his share of the job several letters of the alphabet and worked on one of them at a time until it was completed. He first arranged all the items of his leading letter according to the alphabetical order of their second letters, thus making generally some ten or twelve new groups. Then he laid out in consecutive order the items of each new group on a drawing table in the proper alphabetical order of their third letters, holding them down by means of steel straight edges or T-squares so as to prevent disturbance by the breeze or from any other cause. After getting a bunch of items into final order he wet each slip and gummed it onto a sheet of scratch paper

of letter size, tearing off the initial words in the case of group-indexing, and writing in with pencil in proper order the page numbers on the first slip in case of duplication of any word or subject. After the various main groups were finished, the sheets were arranged in correct alphabetical order and sent to the printer.

It was decided to place the index at the end of the second volume only, and not at the end of each volume; but the page numbers for the latter were set in bold-faced type so as to enable the searcher to see instantly in which volume he must look for the subject desired.

In concluding this paper, the author earnestly requests that all the members of the Society for the Promotion of Engineering Education who are interested directly or indirectly in technical-book writing give it a thorough discussion, in order to obtain a compendium of knowledge concerning the subject; and it would be well also to try to obtain discussions by prominent technical writers who are not members of the Society. Such a consensus of opinion from the highest technical literary authorities of this continent would not only be exceedingly useful to all future writers of engineering books, but also would materially improve the quality and style of American technical literature.

A DEFENSE OF MATHEMATICAL TRAINING.

BY R. F. DEIMEL,

Assistant Professor of Mechanics, Stevens Institute of Technology.

There is no mistaking the first large impression one gets on reading "The Relation of Mathematical Training to the Engineering Profession," by Professors Gaylord and Hanus in the October BULLETIN: it is that engineers are dissatisfied with the results of their mathematical training. Their opinions are summarized thus:

"About 20 per cent. . . . urged more emphasis on the applications of mathematics for students of engineering" (p. 64).

"There is much testimony to the effect that the teaching of mathematics to engineers has been placed either in the hands of the pure mathematician who has neither knowledge nor interest in the engineering practice, or in the hands of an engineer poorly equipped with mathematical knowledge" (p. 69).

"They . . . greatly desire a change of conditions which shall make it possible to produce instructors whose sympathies and training will enable them to combine the two somewhat antagonistic spirits of pure mathematics and engineering practice" (p. 69).

The authors therefore add:

". . . it seems to us, we have the suggestion of a possible remedy for the condition complained of by the engineers—a course given by a thoroughly trained mathematician who has sufficient knowledge and sympathy for the engineering profession to be able to illustrate all the mathematical theory by problems drawn from the engineering field" (p. 71).

On their own evidence, which is hardly to be doubted, lamentably many engineers do not learn to use mathematics

in college. We must not, however, confuse the issue. What concerns those of us engaged in education is whether engineers are *taught* to use mathematics. Colleges throughout the country will answer most emphatically that thorough instruction in the application of mathematics through calculus is given to every student of civil, electrical, and mechanical engineering. I believe the colleges are right. I know that Stevens is right. Every one of its graduates has passed courses in theoretical and applied mechanics, structures, hydraulics, thermodynamics, strength of materials, electricity, and every one of these courses deals with the application of mathematics to engineering problems. What "problems drawn from the engineering field" are not here?

So much for subject-matter. Let us consider now "instructors whose sympathies and training will enable them to combine the two somewhat antagonistic [sic!] spirits of pure mathematics and engineering practice." Church, Ennis, Franklin, Goodenough, Hoskins, Jacoby, Karapetoff, Martin, Maurer, Merriman, Slocum, Spofford, Ziwet are merely a few, named at random, who by training and sympathy are mathematician-engineers. And it cannot decently be assumed that those who expound their texts are conspicuously incompetent.

I have not spoken of the teaching of mathematics, only of teaching its use. I am defending the latter; the former needs even less defense. Mathematical processes and concepts are learned well enough. But clothing physics in mathematical language is to a certain extent creative work in the sense that using an artist's brush or a poetic meter is creative. It can be learned—sometimes. It has been my experience that it is no easier to impart a purely physical idea than a purely mathematical one. Indeed I shall go so far as to maintain that nearly all of an engineering student's trouble with applied mathematics lies in his inability to grasp an essentially physical concept or to focus his attention on one small thing at a time. The day before I read Professors Gaylord and Hanus's important article I spent fifty minutes introducing, *dictating*,

explaining, repeating, and illustrating definitions of shearing force and bending moment. I gave this definition:

"The bending moment at any beam section is the algebraic sum of the moments of the external forces acting on one *or* the other of the two free bodies into which the section divides the beam, the moments to be taken about a transverse axis in the section."

The class had a written quiz on the next fatal day. Here are three answers by young men who had studied entrance physics, college physics, kinematics, statics and kinetics:

"A bending moment is a force applied perpendicular to the length of a beam, supported at two or more points, tending to cause a deflection of the beam."

"Bending moment is the applied force times its distance from the fixed point in a beam."

"Bending moment is moment about the ends of a beam tending to bend it upward or downward."

Were these answers due to faulty memory, faulty thinking, faulty teaching, or faulty learning? Most of the class gave absolutely correct definitions; this proves my thesis that good teaching and good learning are not necessarily simultaneous processes in the classroom. Here in short is the tragedy of education. Some students—not all, not a majority, but an appallingly large minority—cannot learn, and therefore cannot be taught more than to "pass an examination" in certain subjects. Until students are more carefully selected to suit the curriculum, which is of course an absurd thing to do, or until the curriculum is more carefully adapted to the needs, the capacities, and even the tastes of the individual we shall have no more success in teaching than our students at present have in learning. To many engineers, commercial procedure and business economics are, from developmental as well as utilitarian points of view, of inestimably greater value than any mathematics beyond arithmetic. To others calculus is fully as indispensable as addition and subtraction. No happy mean, only gray compromise, can be found for these two equally intellectual groups.

DISCUSSION: "THE RELATION OF MATHEMATICAL TRAINING TO THE ENGINEERING PROFESSION."

(Gaylord and Hanus, Vol. VII, No. 2).

BY L. M. PASSANO,

Massachusetts Institute of Technology.

It seems to the writer that the fundamental error underlying the objections to teaching more or less advanced mathematical subjects to engineering students, and underlying the contention that time so used could be better given to "gaining certain practical knowledge" is this: That the schools are expected to send out after four years' training engineers, full fledged; whereas all that the school can do is to send out fledglings capable of becoming engineers after they have acquired practical knowledge—in practice.

After six years of college and university study the writer entered his profession, the teaching of mathematics. All the "practical knowledge" he had of that profession was got "on the side," but he had received in his college training the ability to grasp and make use of the practical knowledge as it came to him; and it is still coming.

In the category of that training for his profession the writer puts not merely his mathematical studies but *all* that he studied, even including such remotely related subjects as English and foreign literature, history and economics; no one of which is as closely related to his profession as is mathematics to engineering. For after all mathematics is the basis of the sciences, the sciences are the foundation of engineering theory, and engineering theory is the corner-stone of engineering practice.

If practicing engineers will agree to accept the graduates of our schools as potential engineers only, to whom must be

given the impetus of practical knowledge by which they are to become—shall we say?—"kinetic" engineers, then it will soon be granted that what our students need is more rather than less mathematics.

In return the writer will concede that, in some cases, the mathematics should be better taught; and will venture to assert, on the other hand, that the teaching of mathematics is steadily improving, and will continue to improve.

EDITORIAL.

The Congress on Human Engineering held recently at the Ohio State University marks the recognition of a new factor in engineering education. The program was planned to present to the engineering student the subject of the human factor in industry from the point of view of the employer, operating superintendent, engineer, laborer, employment agent, welfare worker, economist and teacher. The addresses emphasized the fact that the engineer must be equipped with a sympathetic knowledge of human nature in order that he may contribute his share to the new movement for industrial peace.

This movement has in it the fundamentals for much good for the student who is to enter the industries. The most striking fact developed by the Congress is that industrial or engineering success for any one man or class of men does not necessarily involve corresponding distress of other men; but rather the contrary. In the estimation of the writer the meeting was a success and an excellent beginning of a movement which we should like to see continue and expand.

PERSONALS.

President Chatburn appointed Professors Dugald C. Jackson and Comfort A. Adams, of the Massachusetts Institute of Technology, as principal and alternate to represent the Society at the meeting of the committee of the Association of American Universities on academic and professional higher degrees held November 8 at the office of Dean Charles H. Haskins, Harvard University.

Mr. W. O. Wiley, treasurer of the Society, spent November 8 and 9 with the secretary going over the affairs of the Society.

A. A. Potter, dean of the Engineering Division, Kansas State Agricultural College, and J. G. Scrugham, dean of the

College of Engineering, University of Nevada, were visitors in the office of the secretary on November 13.

Dr. C. R. Mann, of the Carnegie Foundation for the Advancement of Teaching, and President A. M. Stowe, of Toledo University, were visitors on November 14.

COLLEGE NOTES.

University of Akron.—The engineering college, established in the University of Akron in the fall of 1914 and operating the coöperative plan, has a total enrollment of fifty-three students. Five of these are in Texas taking part in the boundary defense. This year's entering class numbers twenty-two.

Both the institution and the manufacturing organizations are so pleased with the coöperative plan that it has been extended to a course in business training. Students in this course spend two weeks at college and the next two weeks at work in the offices of different business organizations. The plan seems to work as well in this as in the engineering department.

Last year the university established a night college which enrolled one hundred and eight students. This year the work has been extended to include more courses and the enrollment is over three hundred students.

Carnegie Institute of Technology.—Final plans have been drawn for a head house for the school of applied science, which is to cost $300,000. A portion of the building will be four stories high and the remainder ten. Construction work will start as soon as steel deliveries can be made. The structure will house the executive offices and library of the engineering school, and the departments of modern languages, machine design, and commercial engineering.

During October and November meetings have been held at the Institute of the local members of the National Association of Corporation Schools, consisting of representatives from the Carnegie Steel Company, Westinghouse Electric & Mfg. Com-

pany, Pennsylvania Railroad Company, National Tube Company, American Bridge Company, and H. J. Heinz Company, the University of Pittsburgh, the public schools and the Institute. The purpose has been to form a Pittsburgh chapter of the Asscciation, the national executive council in New York having assured favorable action in advance. This movement gives promise of affording opportunities for developing some of the best types of coöperation between educational institutions and large business interests.

Mine rescue work and first aid work constitute recent additions to the course in mining engineering. The instruction is given by the United States Bureau of Mines at the arsenal grounds in Pittsburgh, and is required of all mining seniors. When the Bureau moves shortly to its new building adjoining the Institute campus, the engineering students will not only have the above work near at hand, but will also be able to see much more of the methods used by the Bureau in its investigations and field work.

Dr. Walter Libby has returned to the faculty after a year abroad at Oxford, where he wrote his new book "An Introduction to the History of Science," soon to be published by Houghton, Mifflin & Co. During the first semester he will give a series of lectures on the subjects of his book.

The following are new appointees to the science faculty for 1916–17: Joseph Jensen, assistant professor of mining engineering; T. R. Alexander, Jr., instructor in chemistry; Ross R. Calvin, instructor in English; Arthur W. Cate, instructor in German; J. W. Doolittle, instructor in physics; Robert E. Dunbar, graduate assistant in electrical laboratory; David G. Howard, instructor in electrical engineering; C. D. R. Ingalls, graduate assistant in mechanical laboratory; G. C. Mills, instructor in machine design; J. B. Nathanson, instructor in physics; F. S. Nowlan, instructor in mathematics; F. Allen Simmons, instructor in civil engineering; Vincent H. Todd, instructor in modern languages.

The large exhibit which the United States Steel Corporation had at the Panama-Pacific Exposition has been loaned indefi-

nitely to the Institute, and is now installed in one of the science buildings.

University of Colorado.—The committee on informal faculty meetings of the college of engineering have planned a series of meetings covering the academic year, a prominent feature of which will be addresses by members of the faculties of other colleges in the university. Such addresses will cover the points of contact between the engineering profession and other branches of science and of human interest. The first meeting of the year was held October 12. The address was given by Professor L. W. Cole, head of the department of psychology, his subject being psychology in engineering education.

Iowa State College.—Dr. Charles A. Mann has been appointed associate professor of chemical engineering to succeed Professor George A. Gabriel, who goes into practical work. Dr. Mann comes from the University of Wisconsin, where he was assistant professor of chemical engineering. He has had wide experience as a teacher, and as consulting chemist. Mr. D. P. Weeks was appointed instructor in agricultural engineering to succeed Mr. E. W. Lehmann who resigned. Mr. Weeks' special experience has been along the line of power developing work in Nebraska. Mr. Dean G. Carter was appointed instructor in agricultural engineering to succeed Mr. George Iverson, resigned. Mr. V. L. Chrisler, formerly instructor in physics in the University of North Carolina, has been appointed instructor in physics in this institution. Mr. P. F. Hopkins succeeds Mr. F. A. Dragoun as instructor in civil engineering. Mr. E. W. Kane, formerly with the Allis-Chalmers Company of Milwaukee, has been appointed to an assistant professorship in the electrical engineering department.

The Engineering Society of the College now has 664 members, 627 students and 37 faculty members. This organization controls the general activities of the division.

T. R. Agg, professor of highway engineering, was recently appointed a member of the committee on "Tests and Investi-

gations of the American Association of State Highway Departments."

Massachusetts Institute of Technology.—Stephen Codman, business associate of the late Professor Despradelle, has been appointed associate professor in architecture, Charles Everett has been advanced to the grade of assistant professor and Edwin C. Holbrook has been appointed instructor in architectural engineering.

Probably the most important step forward in years for technical education lies in the establishment by the institute of its station for chemical engineering practise. These will be for the present five in number, each one an institute school with its director, assistant or assistants, with lecture rooms, laboratory and library. Students spending a few weeks at each station will become familiarized by actual contact with the important industrial processes of modern times in chemistry, and will return to Boston for a fifth year at the Institute which under the circumstances will be as valuable as two or three would be without the experience.

Professor W. H. Walker has been made director of the course in chemical engineering practise, and the directors of the stations with the title of assistant professor of chemical engineering are: for the station at Bangor, Hugo H. Hanson, M. I. T.; for Everett, Guy H. Buchanan, Washington and Jefferson and M. I. T.; for Niagara Falls, Dr. Ernest W. Wescott, Harvard and M. I. T.; for Stamford, Leslie T. Sutherland, Cornell and for Allentown, Penn, Samuel H. Salisbury, Jr., Lehigh.

University of Minnesota.—Dean Francis C. Shenehon has been engaged, since the middle of June, as consulting engineer on hydraulic investigations in Illinois and will be absent from the University almost continuously until the middle of December. The investigations are on the Illinois River and became necessary by reason of a controversy between the Marseilles Land and Water Power Company and the Northern Illinois Light and Traction Comapny.

Purdue University.—The university has opened under favorable auspices, there being a larger freshman class than at any previous time in its history. This increase has been in the engineering schools as the entering class in agriculture was less than last year. This tendency is probably due to the stimulus caused by the great volume of war business.

The demand for graduates is unprecedented. In practically every department of engineering there are many more applications for men than there are men to fill them. We are finding it increasingly difficult to secure laboratory assistants and instructors as salaries in these positions are not commensurate with those at present offered in the manufacturing industries.

An imposing building of brick and Bedford stone is being erected this year for the school of science. In floor area it will be one of the largest structures on the campus.

There is considerable development along military lines this year on account of the new military bill and plans are under way for a large armory which will probably be built next year.

Some important research work is being conducted by the different schools. In civil engineering, tests of reinforced concrete floors of actual working dimensions and in mechanical engineering, a detailed survey of the strength of various brake beams used by the railroads are being made.

The following changes have taken place in the staff of the school of mechanical engineering: Professor H. S. Dickerson, after ten years of service, has gone to the school of mines at Rolla, Missouri, as head of the department of mechanical engineering. Mr. F. C. Goldsmith, instructor in design, has resigned to take charge of the efficiency department of the Haynes Automobile Company, Kokomo. Mr. W. H. Severns, instructor in the mechanical laboratory, has been called to the University of New Hampshire as assistant professor of mechanical engineering. Mr. H. B. Ensign, recently of the University of West Virginia, has become instructor in machine design at Purdue University.

Fifteen of the seventeen members of the staff of this department were engaged in engineering work during the summer.

Rutgers College.—Rutgers College, the eighth colonial college to receive its charter, celebrated the 150th anniversary of its founding on October 12 to 15, inclusive, by appropriate ceremonies.

Prominent delegates from about 150 colleges and seminaries, both in this country and abroad, were entertained as guests of the college, the engineering building being their headquarters.

The first day was devoted to an "Education Conference." Among those addressing the conference were United States Commissioner of Education Claxton and Edward Orton, Jr., lately dean of the College of Engineering of The Ohio State University.

Other features of the celebration consisted of an academic procession preceding the commemoration exercises; a pageant enacted at the college farm portraying important events in the history of the college; the anniversary dinner and the conferring of degrees.

Among the honorary degrees conferred were those of LL.D. upon Rufus H. Choate and Chevalier van Rappard and that of D.Sc. upon Baron Shiba of Japan.

The exercises were delightfully and fittingly closed by Vespers Sunday afternoon when talented soloists and a chorus of nearly a hundred voices sang for an hour to a large and appreciative audience.

Throop College of Technology.—The chemistry building of Throop College of Technology is rapidly nearing completion and it is expected that the research laboratories can be occupied during the month of December and that classes can be transferred from the present chemistry laboratories to the new building early in the new year.

New members of the staff appointed since the opening of the college year are J. E. Bell, assistant professor of chemistry, who came to Throop College of Technology from the University of Washington, where he was a member of the staff of the chemistry department, and Henry K. Norton, graduate of Dartmouth College, with a degree of M.A. from Pomona College, instructor in business law.

Professor Clinton K. Judy, of the department of English, is this year on leave of absence for study at Harvard.

A feature of interest in this year's work is the inauguration of graduate work in the college, the initial registration of graduate students being in the chemistry department.

Washington University.—The following changes in the faculty have occurred: William Henry Roever, Ph.D., promoted to associate professor of mathematics; William Clifford Morse, A.M., promoted to assistant professor of geology, and Erwin Hartung, A.M., promoted to instructor in German.

The new appointments include that of George Wilber Moffitt, Ph.D., assistant professor of physics; Hunley Whatley Herrington, Ph.D., acting assistant professor of English; Otto Dunkel, Ph.D., assistant professor of mathematics; Paul Reece Rider, Ph.D., instructor in mathematics; James Terry Duce, A.B., instructor in geology; Thomas John Cutting, instructor in drawing; Ralph Jacob Sapper, B.S., instructor in shop work; Elmer Edward Fickett, B.S., instructor in chemistry; Austin Elliott Fitch, B.S., lecturer in architecture; Benjamin Lusby Simpson, B.S., teaching fellow in architecture; Frank William Bubb, B.S., assistant in electrical engineering; Frederick Burton Langreck, B.S., assistant in chemistry; John Charles Fremont Walker, B.S., assistant in chemistry; John Bertwell Ewing, A.B., assistant in economics.

APPLICANTS FOR MEMBERSHIP.

KENNELLY, A. E., Professor of Electrical Engineering, Harvard University and Massachusetts Institute of Technology, Cambridge, Mass. D. C. Jackson, C. A. Adams.

MACNAUGHTON, EDGAR, Instructor in Mechanical Engineering, Tufts College, Tufts College, Mass. G. C. Anthony, C. H. Chase.

PARMELEE, H. C., President, Colorado School of Mines, Golden, Colo. R. S. Hawley, M. S. Ketchum.

POUND, J. H., Instructor in Mechanical Engineering, Rice Institute, Houston, Tex. Hugh Miller, F. J. Lewis.

ROSE POLYTECHNIC INSTITUTE, Terre Haute, Ind., John White, Acting President.

BOOK REVIEWS.

Contracts, Specifications and Engineering Relations. By DANIEL W. MEAD, Professor of Hydraulics and Sanitary Engineering, University of Wisconsin. McGraw-Hill Book Company. 1916. xi–535 pages. 6 × 9, cloth. Price $3.00.

The first part of this book is devoted to the technical and ethical qualifications demanded by the profession and is well worth a very careful study by all students of engineering, especially the first and second year men. Several chapters are inserted regarding possible special work which the engineer may be called upon to do, and defines clearly the duties to client and profession—facts which practicing engineers, as well as engineering students, might do well to read. After comparing the various labor systems employed in executive contract work, the author proceeds to a very excellent discussion of the preparation and interpretation of specifications for construction work.

A large number of excellent examples are quoted to illustrate various points in the text. The appendices covering the last 150 pages contain outline specifications for structural work, sewers, etc., sample contracts and specification drawings for practice in specification writing and a carefully prepared bibliography of specifications covering practically all materials of engineering construction. As a whole, the text presents in clear and logical form facts which every engineering student and many practicing engineers will find of very great value, and the use of such a book as a text in technical schools should meet with great favor.

J. W. H.

Problems in Physics. By WILLIAM D. HENDERSON, Associate Professor of Physics, University of Michigan. McGraw-Hill Book Co. 1916. 6¼ × 9¼, cloth. 205 pp. Price $1.50.

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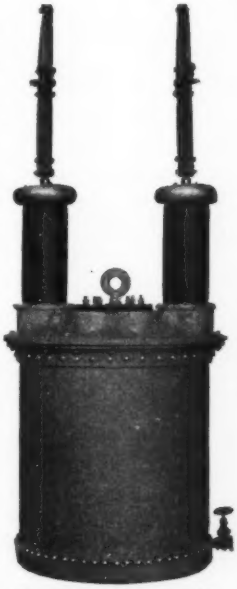

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